

1 Structural Support Beam

2

3 This invention relates to a structural support beam
4 manufactured from a composite of materials, and in
5 particular, but not exclusively, to a composite of
6 timber in various forms with an infill of material
7 that provides both added structural support and
8 thermal/sound insulation, for use in the building
9 and construction industry.

10

11 Support beams of the form of Laminate Veneer Lumber
12 (LVL), Parallam products, Glulam products, I-joists
13 and Box Beams, are known. These different support
14 beams offer different structural properties and are
15 used in different designs for different
16 applications. For example, Parallam products have a
17 high stiffness and strength compared to the other
18 above-mentioned beams, but are heavier, more
19 abrasive to saw and drill, require connection be
20 made to adjacent beams with metal plates and bolts
21 or dowels rather than nails, and are relatively
22 costly; LVL products provide strength and consistent

1 performance, are easy to work with, can be cut and
2 nailed on site, resist shrinkage, warping, splitting
3 and checking, but are relatively costly.

4

5 Box beams are also known as shown in Fig.1. These
6 typically consist of solid timber or LVL flanges
7 with plywood or Oriented Strand Board (OSB) webs.
8 The webs are glued and/or mechanically connected to
9 the flanges on each side to form a box shape.

10

11 Box beams are moderately lightweight, can be handled
12 easily, allow a higher load capacity than comparable
13 sized timber, resist shrinkage, warping and checking
14 and are more efficient than solid timber for large
15 spans and loads.

16

17 However, such box beams are susceptible to shear
18 buckling and therefore require web stiffeners to be
19 positioned at points of increased load to counter
20 localised web buckling. Furthermore, holes in the
21 web can only be located where shear loads are low.

22

23 According to a first aspect of the present invention
24 there is provided a structural support beam for use
25 in building and construction comprising a support
26 frame defining at least one volume, said support
27 frame being of a first material and said at least
28 one volume being in-filled with a second material.

29

30 Preferably, the support frame comprises two spaced
31 apart flanges connected by at least two outer
32 support webs.

1
2 Preferably, each outer support web connects lateral
3 portions of the flanges.

4
5 Optionally, one or more additional outer support
6 web(s) is/are positioned over one or both of the
7 existing outer support webs.

8
9 Preferably, one or more inner support webs connect
10 the flanges in an intermediate position between the
11 outer support webs.

12
13 Optionally, one or more formations are provided in
14 each flange to accommodate the outer support webs.

15
16 Optionally, one or more formations are provided in
17 each flange to accommodate the inner support web or
18 webs.

19
20 Preferably, the formations are one or more of
21 grooves, recesses and cut-out portions.

22
23 Preferably, the flanges are rectangular in shape.

24
25 Preferably, each flange is fully interposed between
26 the outer support webs.

27
28 Optionally, each flange is provided with a reduced
29 width portion to define a T-shaped flange.

30
31 Preferably, each reduced width portion is fully
32 interposed between the outer support webs.

1

2 Preferably, the lateral edges of the other portions
3 are adapted to be flush with the outer surfaces of
4 the outer support webs.

5

6 Alternatively, the lateral edges of the other
7 portions are adapted to extend beyond the outer
8 surfaces of the outer support webs.

9

10 Optionally, a further end-flange is connected to the
11 outer end of each existing flange.

12

13 Preferably, the lateral edges of each end-flange are
14 adapted to be flush with the outer surfaces of the
15 outer support webs.

16

17 Alternatively, the lateral edges of each end-flange
18 are adapted to extend beyond the outer surfaces of
19 the outer support webs.

20

21 Optionally, metal end plates are connected to the
22 outer end of each flange.

23

24 Optionally or additionally, the metal end plates are
25 connected to the outer end of each end-flange.

26

27 Preferably, the second material is less dense than
28 the first material.

29

30 Preferably, the second material is a plastics foam
31 material.

32

1 Preferably, the second material is adapted to give
2 the support beam improved thermal and/or sound
3 insulating properties.

4

5 Alternatively or additionally, the second material
6 is adapted to give the support beam improved
7 structural properties.

8

9 Preferably, the support frame is made from timber
10 materials.

11

12 According to a second aspect of the present
13 invention there is provided a structural support
14 beam for use in building and construction comprising
15 a timber based support frame formed from two spaced
16 apart rectangular flanges connected by at least two
17 outer support webs wherein the timber based support
18 frame defines at least one volume in-filled with a
19 plastics foam material; and wherein the plastics
20 foam material is bonded to the flanges and webs.

21

22 Preferably, the outer support webs extend over the
23 full depth of the flanges.

24

25 Preferably, the flanges are formed from solid or
26 laminated timber material and the webs are formed
27 from timber sheet material.

28

29 According to a third aspect of the present invention
30 there is provided a method of manufacturing the
31 structural support beam of the first aspect, said
32 method comprising the steps of:

- 1 (i) connecting two spaced apart flanges by means of
2 at least two outer support webs to form a
3 support frame defining at least one volume; and
4 (ii) filling said at least one volume with an in-
5 fill of material.

6

7 Preferably, the method comprises the additional step
8 of bonding said in-fill of material to the support
9 frame.

10

11 Preferably, the method comprises the further
12 additional step of gluing and/or mechanically fixing
13 the outer support webs to the flanges.

14

15 Embodiments of the present invention will now be
16 described, by way of example only, with reference to
17 the accompanying drawings in which:-

18

19 Fig. 1 is a cross-sectional view of a known box
20 beam;

21

22 Fig. 2 is a cross-sectional view of a support
23 beam made in accordance with the present
24 invention;

25

26 Figs. 3a-b are cross-sectional views of the
27 apparatus of Fig. 2 with additional end-flanges
28 to form an I-beam showing fasteners visible
29 from the outside, and not visible from the
30 outside, respectively;

31

32 Figs. 4a-b are cross-sectional views of the

1 apparatus of Fig. 2 with additional end-flanges
2 to form a box beam showing fasteners visible
3 from the outside, and not visible from the
4 outside, respectively;

5

6 Fig. 5a is a cross-sectional view of the
7 apparatus of Fig. 2 with an additional inner
8 support web;

9

10 Fig. 5b is a cross-sectional view of the
11 apparatus of Fig. 2 with two additional inner
12 support webs;

13

14 Figs. 5c-d are cross-sectional views showing
15 alternative profiles of the connections of the
16 inner support webs to the flanges.

17

18 Figs. 6a-b are cross-sectional views of the
19 apparatus of Fig. 2 with an additional lateral
20 support web connected to one and both of the
21 outer face(s) respectively of the apparatus of
22 Fig. 2;

23

24 Fig. 7 is a cross-sectional view of an
25 alternative support beam having T-flanges to
26 form an I-beam;

27

28 Fig. 8 is a cross-sectional view of an
29 alternative support beam having T-flanges to
30 form a box beam;

31

32 Fig. 9 is a cross-sectional view of an

1 alternative beam support having grooved flanges
2 to form an I-beam;

3

4 Fig. 10 is a cross-sectional view of a further
5 alternative beam support having recessed
6 flanges to form an I-beam;

7

8 Fig. 11 is a cross-sectional view of an
9 alternative support beam having rectangular
10 flanges to form an I-beam;

11

12 Fig. 12 is a cross-sectional view of the
13 apparatus of Fig. 11 having additional supports
14 at the junctions between the flanges and the
15 lateral support webs;

16

17 Fig. 13 shows cross-sectional views of adapted
18 embodiments of the present invention: (a) is
19 the apparatus of Fig. 2 with metal end plates
20 added to the flanges; (b) is the apparatus of
21 Fig. 3a having metal end plates added to the
22 flanges; (c) is an alternative arrangement to
23 (b); (d) is the apparatus of Fig. 8 with metal
24 end plates added to the flanges; (e) is the
25 apparatus of Fig. 9 with metal end plates added
26 to the flanges; (f) is the apparatus of Fig. 5
27 adapted with both additional end-flanges and
28 metal end plates;

29

30 Fig. 14 is a comparison of the load-deformation
31 characteristics of a sample of embodiments made
32 in accordance with the present invention under

1 direct compression loads; and

2

3 Fig. 15 is a qualitative table comparing known
4 support beams to those of the present
5 invention.

6

7 Referring to the drawings, Fig. 1 shows a known box
8 beam 10 consisting of two spaced apart horizontal
9 flanges 16, 18 connected by the respective ends of
10 two opposing vertical webs 12, 14 to form a box
11 shape. Typically, the webs 12, 14 are glued to the
12 flanges 16, 18 and/or mechanically connected during
13 manufacture. Throughout the specification, the term
14 "box beam" is used to refer to a beam having an
15 overall rectangular shape.

16

17 In a first embodiment of the present invention, as
18 shown in Fig. 2, there is a structural support beam
19 in the form of a box beam 100. The term "structural support
20 beam" used throughout the specification is
21 intended to refer to support beams possessing
22 structural characteristics suitable for use as load-
23 bearing flexural members. The structural support
24 beam comprises two flanges 116, 118 connected by the
25 respective ends of two opposing laterally arranged
26 vertical support webs 112, 114 to form a support
27 frame in the shape of a box.

28

29 The outer support webs 112, 114 are glued and or
30 mechanically connected to the flanges 116, 118.
31 Typically, the flanges are of solid sawn timber,
32 Glulam or LVL, and the webs are of a timber sheet

1 product such as plywood or Oriented Strand Board
2 (OSB).

3

4 The box beam 100 further includes an infill of
5 support/insulating material 110 within a volume
6 defined by the outer support webs 112, 114 and
7 flanges 116, 118. The material 110 is less dense
8 than the timber material from which the flanges and
9 outer support webs are formed.

10

11 The material 110 is a plastics foam, for example,
12 expanded polystyrene (EPS), extruded polystyrene,
13 urethane, or other similar insulation cores that are
14 bonded to the outer support webs 112, 114 and
15 flanges 116, 118 to form a close contact. The
16 material 110 may be of any type to improve both the
17 insulation (thermal and/or sound) and/or structural
18 properties of the box beam 100. The material 110
19 may be bonded to the interior surfaces of the outer
20 support webs 112, 114 and the flanges 116, 118.

21

22 In a second embodiment of the present invention, as
23 shown in Figs. 3a-b, there is a structural support
24 beam in the form of an I-beam 200 comprising
25 substantially the same box beam 100 as described
26 above with the addition of further end-flanges 220,
27 222 (which will hereinafter be referred to as I-
28 flanges) connected to flanges 116, 118 (which will
29 hereinafter be referred to as box-flanges) to form
30 an I-shaped support frame. The I-flanges 220, 222
31 are glued and/or mechanically connected to the box-
32 flanges 116, 118. Mechanical connectors can either

1 be located through the I-flanges to the box-flanges
2 as shown in Fig. 3a or can be located from the box-
3 flanges to the I-flanges as shown in Fig. 3b so as
4 not to be visible from the outer surface of the I-
5 beam 200.

6

7 In a third embodiment of the present invention, as
8 shown in Figs. 4a-b, there is a structural support
9 beam in the form of a box beam 300 comprising
10 substantially the same box beam 100 as described
11 above with the addition of further end-flanges 320,
12 322 (hereinafter referred to as flush-flanges) the
13 lateral edges of which are adapted to be flush with
14 the outer surfaces of the opposing laterally
15 arranged outer support webs to form a box beam. The
16 flush-flanges 320, 322 are glued and/or mechanically
17 connected to the box-flanges 116, 118. Mechanical
18 connectors can either be located through the flush-
19 flanges to the box-flanges as shown in Fig. 4a or
20 can be located from the box-flanges to the flush-
21 flanges as shown in Fig. 4b so as not to be visible
22 from the outer surface of the box beam 300.

23

24 In a fourth embodiment of the present invention, as
25 shown in Fig. 5a, there is a structural support beam
26 in the form of a boxed I-beam 400 comprising
27 substantially the same box beam 100 as described
28 above with the addition of a further inner support
29 web 424 connecting box flanges 416, 418. The inner
30 support web 424 lies parallel with the opposing
31 outer support webs 112, 114 in an intermediate
32 position between the outer support webs. The box

1 flanges 416, 418 are each provided with a groove
2 426, 428, each groove being adapted to receive a
3 respective end of the inner support web 424 and
4 retain it in position within the respective box
5 flanges 416, 418. The web 424 may be rigidly fitted
6 within the grooves 426, 428 and/or glued and/or
7 mechanically connected. Fig. 5b shows a structural
8 support beam as described in the previous paragraph
9 having two inner support webs 424 to form a boxed
10 double I-beam. The in-fill material may be bonded
11 to the interior surfaces of the outer support webs
12 112, 114 and the flanges 116, 118 and to both
13 surfaces of the inner support web(s).

14

15 Figs. 5c-d show alternative profiles of the
16 connections between the inner support webs 424 and
17 the grooves 426, 428. Fig. 5c shows an inner
18 support web 424 having a rectangular end profile and
19 Fig. 5d shows an inner support web having a tapered
20 end profile.

21

22 In a fifth embodiment of the present invention, as
23 shown in Figs. 6a-b, there is a structural support
24 beam in the form of a box beam 500 comprising
25 substantially the same box beam 100 as described
26 above with additional laterally arranged outer
27 support webs 513, 515 being connected to the outer
28 surface of one or both outer support webs 112, 114.
29 The additional laterally arranged outer support webs
30 513, 515 could be glued and/or mechanically
31 connected to their respective outer support webs
32 112, 114.

1
2 In a sixth embodiment of the present invention, as
3 shown in Fig. 7, there is a structural support beam
4 in the form of an I-beam 600 comprising two T-shaped
5 flanges 616, 618, (T-flange 616 being inverted),
6 connected by the respective ends of two opposing
7 outer support webs 612, 614 to form an I-shaped
8 support frame. Each T-shaped flange comprises a
9 reduced diameter stem portion. The stem portions
10 are formed by cutting away two rectangular corner
11 portions from a regular rectangular flange. The
12 outer support webs 612, 614 can be glued and/or
13 mechanically connected to the lateral sides of the
14 stem portions of the T-shaped flanges 616, 618. The
15 outer support webs 612, 614 and flanges 616, 618
16 define a volume having an infill of
17 support/insulating material 610 substantially the
18 same as material 110 as hereinbefore described.

19
20 In a seventh embodiment of the present invention, as
21 shown in Fig. 8, there is a structural support beam
22 in the form of a box beam 700 comprising two T-
23 shaped flanges 716, 718, (T-flange 716 being
24 inverted), the lateral edges of which are adapted to
25 be flush with the outer surfaces of the opposing
26 outer support webs 712, 714 to form a box beam. The
27 outer support webs 712, 714 can be glued and/or
28 mechanically connected to the stem portions of the
29 T-shaped flanges 716, 718. The webs 712, 714 and
30 flanges 716, 718 define a volume having an infill of
31 support/insulating material 710 substantially the
32 same as material 110 as hereinbefore described.

1

2 In an eighth embodiment of the present invention, as
3 shown in Fig. 9, there is a structural support beam
4 in the form of an I-beam 800 comprising two double
5 grooved flanges 816, 818 connected by the respective
6 ends of two opposing outer support webs 812, 814 to
7 form an I-shaped support frame. The respective
8 outer support webs 812, 814 are each located within
9 grooves 824a-826b provided on the double grooved
10 flanges 816, 818. The outer support 812, 814 may be
11 rigidly fitted within grooves 824a-826b and/or glued
12 and/or mechanically fastened to the double grooved
13 flanges 816, 818. The outer support webs 812, 814
14 and double grooved flanges 816, 818 define a volume
15 having an infill of support/insulating material 810
16 substantially the same as material 110 as
17 hereinbefore described.

18

19 In a ninth embodiment of the present invention, as
20 shown in Fig. 10, the I-beam 800 has been adapted to
21 form a new structural support beam or I-beam 900.
22 Single recesses 925, 927 replace the double grooves
23 824a-826b of the flanges 816, 818. The outer
24 support webs 812, 814 can be accommodated within
25 part of each single recess 925, 927 and an infill of
26 support/insulating material 910 substantially the
27 same as material 110 as hereinbefore described is
28 provided in the volume defined by the outer support
29 webs and the single recessed flanges.

30

31 In a tenth embodiment of the present invention, as
32 shown in Fig. 11, there is a structural support beam

1 in the form of an I-beam 1000 comprising two
2 rectangular I-flanges 1016, 1018 connected between
3 respective ends of two outer support webs 1012, 1014
4 to form an I-shaped support frame. The outer
5 support webs 1012, 1014 and flanges 1016, 1018
6 define a volume having an infill of
7 support/insulating material 1010 substantially the
8 same as material 110 as hereinbefore described.

9

10 In an eleventh embodiment of the present invention,
11 as shown in Fig. 12, the I-beam 1000 has been
12 adapted to form a new structural support beam or I-
13 beam 1100, wherein, support members 1101-1104 are
14 glued and/or mechanically connected at the junction
15 region between the ends of outer support webs 1012,
16 1014 and the I-flanges 1016, 1018.

17

18 It will be appreciated by those skilled in the art
19 that mechanical fixing of the outer support webs and
20 flanges can be carried out by any suitable means,
21 for example by nails, staples, screws, bolts etc.

22

23 It will further be appreciated that each of the
24 foregoing embodiments can be adapted or modified to
25 include features of any of the other embodiments.
26 For example, the additional inner support web(s) of
27 Figs. 5a-b may be easily incorporated into any of
28 the other embodiments. Equally, any one of the
29 embodiments can easily be modified or adapted to
30 give improved structural properties. For example,
31 Fig. 13 shows how some of the embodiments may be
32 fitted with metal plates to improve their structural

1 characteristics.

2

3 Moreover, it will be appreciated by those skilled in
4 the art that the integrity of the flanges affects
5 the structural qualities of a support beam. In
6 particular, the connection of the outer support webs
7 to the flanges is an important area in terms of
8 structural integrity. For example, the absence of
9 grooves, recesses and cut out portions in otherwise
10 rectangular shaped flanges (e.g. see Figs. 2-4, 6
11 and 11-13c) offers several advantages. By
12 rectangular, it is meant that the flanges are of a
13 regular four-sided rectangular or square shape
14 without any formations such as grooves recesses or
15 cut-out portions to accommodate the outer support
16 webs. Rectangular flanges offer several advantages
17 as follows: (i) Ease of Construction - the
18 simplicity of the design avoids the need for
19 expensive grooving and close tolerances; (ii)
20 Strength and Stiffness - the presence of grooves or
21 recesses within the flanges creates areas of
22 weakness and hence reduces the bending and
23 longitudinal shear strength capacity of the
24 structural beam. For a set beam depth (often
25 governing the design and detailing criteria), a box
26 shaped design such as that shown in Fig. 2 will
27 provide a stronger beam in bending (due to the fully
28 intact flanges) and in shear (due to outer support
29 webs extending to the full depth of the flanges) and
30 therefore an overall stiffer solution; (iii) Greater
31 Dimensional Stability - the absence of grooving
32 increases dimensional stability and reduces the

1 possibilities for differential shrinkage in flanges
2 which can lead to cracking; and (iv) Cost - grooving
3 is an expensive part of the manufacturing process
4 both in terms of preparation and assembly as
5 specialised jigs and clamps are required. The
6 exclusion of grooves and recesses thus leads to a
7 lower cost solution with the added benefit of
8 performance gains.

9

10 The support beams of the present invention
11 incorporate both structural and insulation qualities
12 into a single member during manufacture thus
13 achieving higher quality, more accurate thermal
14 and/or sound efficiency and an increased level of
15 structural support.

16

17 The structural beams of the present invention can
18 also be produced in varying sizes and thickness
19 depending on the particular application and
20 insulation/structural requirements.

21

22 The material 110-1010 not only provides thermal
23 and/or sound insulation, but also provides increased
24 structural properties as demonstrated by Fig. 14,
25 the results of which are described below.

26

27 Samples of the aforementioned embodiments described
28 above have been tested (under static compression) to
29 establish their structural properties. The
30 apparatus tested was:

31

32 (A) and (B) which are the support beams of Figs. 2

1 and 1, i.e. with and without the infill of material
2 110 respectively;

3
4 (C) and (D) which are the support beam of Fig. 9 and
5 a corresponding support beam without an infill of
6 material respectively;

7
8 (E) and (F) which are the support beams of Fig. 5a
9 and a corresponding support beam without an infill
10 of material respectively; and

11
12 (G) and (H) which are the support beams of Fig. 8
13 and a corresponding support beam without an infill
14 of material respectively.

15
16 For all support beams, corresponding flanges were
17 cut from Whitewood grade C16 timber. The
18 corresponding outer support webs were cut from 11mm
19 thick OSB grade 3 panels and the infill material was
20 95mm thick expanded polystyrene (EPS). All contact
21 surfaces were glued together, and where appropriate,
22 were screwed using 2x8 woodscrews.

23
24 In comparing the support beams with the infill of
25 material (A, C, E and G) and without the infill of
26 material (B, D, F and H), there is generally an
27 increase in the ultimate load capacity and ductility
28 of the support beams having the infill of material.

29
30 Advantageously, the infill material adds very little
31 overall weight to each support beam, yet it provides
32 a significantly increased ultimate load capacity.

1 Furthermore, the requirement for I-beams and box
2 beams to have web stiffeners at areas prone to
3 localised buckling may be dispensed with due to the
4 increased ultimate load capacity of the support
5 beams having the infill of material.

6

7 Moreover, the results shown in Fig. 14 show that the
8 support beams having the infill of material (A, C,
9 E, G) can carry the same load for an increased
10 deflection/displacement, i.e. they have enhanced
11 ductility qualities.

12

13 In particular, supports beams (C) and (D) are worthy
14 of further comment. The infill of material in
15 support beam (C) exhibits an interesting quality in
16 that it appears to affect the failure mode of the
17 support beam. Although support beam (D) appears to
18 fail suddenly at a displacement of approximately
19 4mm, support beam (C) appears to initially fail at a
20 displacement of approximately 5mm yet can still hold
21 the load applied for a further 4mm of displacement.
22 This shows the level of enhanced ductility provided
23 by the infill material of support beam (C).

24

25 Overall the results clearly demonstrate that the
26 addition of an inner support web connected between
27 the flanges within the infill of material exhibit a
28 far higher ultimate load capacity. From this
29 result, it can be extrapolated that the addition of
30 one or more inner support web(s) may increase the
31 ultimate load capacity of any support beam design.

32

1 Having conducted the above tests, Fig. 15 shows a
2 qualitative comparison of the structural support
3 beams of the present invention with known designs.

4

5 The structural support beams of the present
6 invention may be used in any building and
7 construction projects. The support beams may be in
8 the form of I-beams, double I-beams, box-beams,
9 boxed I-beams or boxed double I-beams.

10

11 Modifications and improvements may be made to the
12 above without departing from the scope of the
13 present invention. For example, the infill
14 material 110-1010 may be pre-fabricated, in which
15 case, the respective outer support webs and flanges
16 of a support frame may be bonded directly to the
17 pre-fabricated material 110-1010. The infill
18 material may be formed from either open cell, closed
19 cell or a mixture of open and closed cell foam
20 materials. Alternatively, the infill material may
21 be formed from a wood-based material or any other
22 suitable material providing the desired structural
23 and/or thermal/sound insulating properties.

24

25 Alternatively, the material 10-1010 may be injected
26 into a volume defined by a support frame of outer
27 support webs and flanges, wherein the material
28 expands to fill the volume. The respective contact
29 surface of the support frame may have bonding means
30 to assist on securing and ensuring a close contact
31 with the infill of material 10-1010 to the support
32 frame.